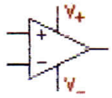
OPERATIONAL AMPLIFIERS



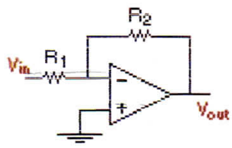
The Operational Amplifier has two voltage supplies +V and -V which are usually omitted from schematics. The other two inputs marked with a - and a + are called the inverting input and the non-inverting input respectively. How these inputs are used determines what the output signal will be.

See Field Effect Transistors for information on the theory for the construction of the Op Amp.

Ideal Operational Amplifier	*Real Operational Amplifier*
Gain = ∞ $\mathbf{R_{in}}$ very high $\mathbf{R_{out}} = 0$ $v_- = v_+$ $\mathbf{I_{in}} = 0$	Gain ~ 80 to 100 *dB* $\mathbf{R_{in}}$ ~ 10^{10} to 10^{12} $\mathbf{R_{out}}$ is small ~ 10 Ω $\mathbf{V_{out}} = \mathbf{A_v}\,(v_+ - v_-)$ $v_+ - v_-$ is small $\mathbf{I_{in}}$ is very small ~ 10^{-12} *A*

This table can be used for linear applications of operational amplifiers only. In non-linear applications $v_{out} \neq A_v\,(v_+ - v_-)$

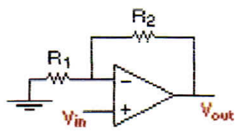
Inverting Amplifiers



When the input goes more positive, the output goes more negative (and vice vesa).

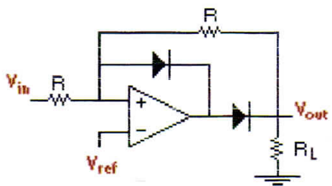
Gain = $-\mathbf{R_2} / \mathbf{R_1}$

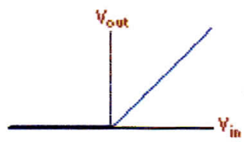
Noninverting Amplifiers



Gain = $1 + \mathbf{R_2} / \mathbf{R_1}$

Perfect Diode





The perfect diode overcomes the imperfection of the diode, by rectifying very small voltages without clipping.

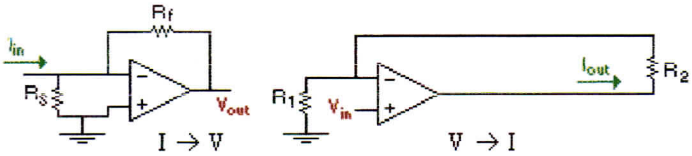
Diodes may be switched for the opposite effect (mirrored about the $\mathbf{V_{out}}$ axis). When $\mathbf{V_{ref}} = 0$ is shown. $\mathbf{V_{ref}}$ may be changed to offset the corner point on $\mathbf{V_{in}}$ axis.

Low Pass Filters

Butterworth	Bessel	Chebyshev
maximally flat prevents aliasing good for data acquisition all points pass through -3 dB	*linear phase* time delay	*sharp cut-off* high selectivity non-linear phase responce

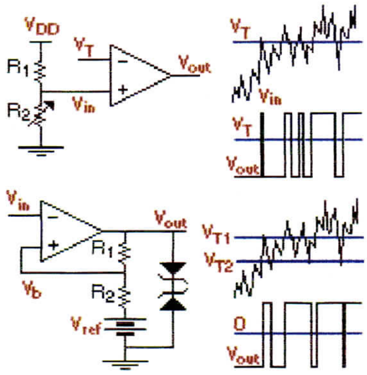
Transconductance Amplifier

I to **V** is like an ideal amplifier. **V** to **I** allows a voltage to be measured from a long distance away.



Threshold Detector

Tend to have +ve feedback, and cannot be analysed using linear equations.

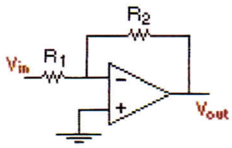


example

$$V_{T1} = V_{b1} = [\, R_2 / (R_1 + R_2) \,] (V_{zener} - V_{ref}) + V_{ref}$$
$$V_{T2} = V_{b2} = [\, R_2 / (R_1 + R_2) \,] (-V_{zener} - V_{ref}) + V_{ref}$$

Sensitivity

Sensitivity is how the circuit characteristic changes depending on an the op-amps' characteristic (finite gain) For the basic op-amp circuit shown, The gain of the op-amp is given by A_v, while the gain of the circuit is given by K_v.



$A_v = -R_2 / R_1$ (ideal only)

$A_v = V_{out} / (V_+ - V_-)$ (non ideal)

$K_v = [-R_2 / R_1] / [1 + (1 / A_v) (1 + R_2 / R_1)]$

sensitivity = $\Delta K_v / \Delta A_v$ (absolute)

sensitivity = $(\Delta K_v / K_v) / (\Delta A_v / A_v)$ (relative)